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# IMPACT OF CU ON AUXILIARY, OPTICAL AND ELECTRICAL CHARACTERISTICS OF $SNO_2$ NANOPARTICLES

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## ABSTRACT

Unadulterated and Cu doped $SnO_2$ nanopowders have been blended by concoction precipitation technique utilizing $SnCl_4.5H_2O$, $NH_3.H_2O$ and $CuSO_4.5H_2O$ as crude materials. The items have been tempered at 600°C for 5 hours under encompassing condition so as to enhance the crystallinity. Powder XRD results demonstrate that the specimens solidify in tetragonal rutile sort $SnO_2$ stage. The normal crystalline size of unadulterated $SnO_2$ is observed to associate with 10 nm. The precious stone structure of the $SnO_2$ does not change with the presentation of Cu, but rather the crystalline size declines to 8 nm and 6.5 nm for Cu doping of 10 and 20 wt. % individually. These outcomes have been affirmed by the transmission electron microscopy (TEM) thinks about. UV-VIS dissemination reflectance spectroscopy (DRS) uncovered the band hole energies to be 3.56, 3.31, 3.28 eV for immaculate and Cu (10 and 20 wt. %) doped $SnO_2$ separately. Temperature subordinate resistivity estimation demonstrated that both the immaculate and Cu doped specimens are appropriate for gas detecting applications. The electrochemical way of the examples has been concentrated on utilizing cyclic voltammetric strategy.

**KEYWORDS:** $SnO_2$, Copper Doping, UV-VIS DRS, TEM, Cyclic Voltammetry

## INTRODUCTION

Move – metal oxide nonmaterial's, for example, $SnO_2$, ZnO, $TiO_2$ and $WO_3$ have pulled in broad examination intrigues inferable from their special physical and compound properties and differing potential applications in optical and electronic fields. $SnO_2$ is a wide band crevice (Eg= 3.6 eV) semiconductor with n-sort conduction because of the presence of inborn deformities and has been broadly utilized as a part of numerous fields, for example, photo catalysis, straightforward leading terminals for level board shows and sun oriented cells, gas sensors and oxidation impetus, attributable to its extraordinary optical and electrical properties went with super mechanical and compound soundness [1]. Numerous procedures have been created for the combination of $SnO_2$ nanostructures, e.g. shower pyrolysis [2], aqueous techniques [3], vanishing tin grains in air [4], compound vapor testimony (CVD) [5], warm dissipation of oxide powders [6], quick oxidation of essential tin [7] and sol–gel strategy [8]. Doping with CuO has been appeared to upgrade the affectability and selectivity of $SnO_2$ toward $H_2S$. In contrast with immaculate $SnO_2$, $SnO_2$: CuO movies demonstrate a high resistivity in air which radically drops in nearness of H2S or other sulfur mixes. This conduct has been ascribed to the arrangement of p–n heterojunctions (p-CuO and n-$SnO_2$), which prompts an electron drained space charge layer at the surface of $SnO_2$. Upon presentation to $H_2S$, the p-sort semi-directing CuO particles are changed over to CuS having metallic properties [9]. $SnO_2$ nanoparticles have been effectively doped with uncommon earth particle ($Tb^{3+}$, $Eu^{3+}$, and $Ce^{3+}$) and move metal particle ($Mn^{2+}$) [10]. Numerous outcomes have demonstrated that the few added substances (metal cations: Al, Co, Fe, Cu) can prompt an expansion in the surface region of $SnO_2$ based powders [11]. Lee et al. reported that

the additional dynamic component (Eu) balance out the $SnO_2$ surface and advance reduction in grain size [12]. Gong Zhang et al. [13] have arranged sol gel inferred CuO doped $SnO_2$ nanosized powder for gas sensor applications and got grain size in the request of 20nm. More et al. reported the consolidation of 9 wt% of Cu in $SnO_2$ by dissolvable dissipation strategy and explored the way of gas detecting conduct at different strengthened temperatures [14]. Hu et al. contemplated the impact of Cu and Rh on optical properties of $SnO_2$ nanocrystallites and reasoned that the do pant Cu prompts more compelling limitation of free electrons at the surface imperfections of the host material than Rh dopant [15]. Most studies reported in the writing have managed essentially with gas affectability and conductivity of the tin dioxide doping frameworks and less care has been given to the microstructure and optical parameters [15]. In the present work we have combined immaculate and Cu doped $SnO_2$ nanopowders with two Cu doping centralizations of 10 and 20 wt. % utilizing concoction precipitation system. The doping impact of Cu metal particles on the structure, optical, electrical and electrochemical properties of $SnO_2$ nanocrystalline materials have been explored.

## TEST TECHNIQUE

The immaculate and Cu doped $SnO_2$ nanopowders were set up by substance precipitation strategy. In an average test technique, $SnCl_4.5H_2O$ (logical evaluation) was broken down in deionized water to make 0.1M arrangement. At that point $NH_3.H_2O$ was included into the arrangement drop insightful under solid mixing until the pH of the arrangement scopes to 8. At the point when the response finished, an azury encourage was acquired. This hasten was washed with deionized water more than 5 times to expel the Cl-particles. At that point the item was dried at 105°C for 5 hours. The last item was white shading powder. Cu doped $SnO_2$ were set up in a comparative way, by including 10 and 20 wt. % of $CuSO_4.5H_2O$ into $SnCl_4.5H_2O$ arrangement. In both cases, the items were light greenish in shading. At last, both the unadulterated and Cu doped $SnO_2$ powders were toughened at 600°C for 5 hours under encompassing environment.2.1 Characterization

The readied powders were painstakingly subjected to the accompanying portrayal ponders. Powder XRD example was recorded on Bruker diffractometer inside the 2θ scope of 10 to 80° utilizing CuKα as X-beam source (λ = 1.5406Å). Transmission Electron Microscopy (TEM), Selected-territory Electron Diffraction (SAED) was recorded on a Technai G20-stwin High Resolution Electron Microscope (HRTEM) utilizing a quickening voltage of 200 kV. The optical properties were broke down by UV-VIS dispersion reflectance spectroscopy utilizing CARY 5E UV-VIS-NIR spectrophotometer in the wavelength scope of 200 – 800 nm. Every one of the specimens were squeezed into pellet shape and contacts were made utilizing silver glue as anode and the temperature subordinate resistance estimations were performed by four-test terminal strategy.

## RESULTS AND DISCUSSIONS

### XRD Analysis

Figure1 demonstrates the XRD example of unadulterated and Cu (10 and 20 wt. %) doped $SnO_2$ nanopowders strengthened at 600°C for 5 hours. Every one of the specimens are distinguished as tetragonal rutile sort $SnO_2$ stage and the outcomes are in great understanding Cyclic voltammetric (CV) examinations were performed with a CHI 760 electrochemical analyzer, in single compartmental cells utilizing tetrabutylammonium per chlorate as a supporting electrolyte. The electrochemical conduct of immaculate and Cu (20 wt. %) doped $SnO_2$ at a sweep rate of 0.1 Vs−1 in the potential territory +2.0 to - 2.0 V were recorded. The accompanying three-cathode arrangement was utilized; a shiny

carbon terminal as the working anode, a Pt-wire as the assistant anode, and an Ag/AgCl terminal as the reference cathode with the standard JCPDS (41-1445) information. It can be noticed that there are no tops relating to Cu or CuO stage. This prompts the conclusion that doping of $SnO_2$ with Cu has happened. There are two conceivable doping systems of $SnO_2$ with Cu: substitution and interstitial. For our situation some $Sn^{4+}$ particles are supplanted with $Cu^{2+}$ particle in light of the similar radii of Sn4+ and $Cu^{2+}$ (0.57Å and 0.69Å, separately) [16]. The oxygen-particle opportunities made by substitution doping of $Sn^{4+}$ with $Cu^{2+}$ are charged remunerated by electron gaps, if the specimen is toughened in air. The cross section parameters (a and c) and unit cell volume diminishes after doping of Cu (see table.1). These outcomes are in great concurrence with the writing values [16].

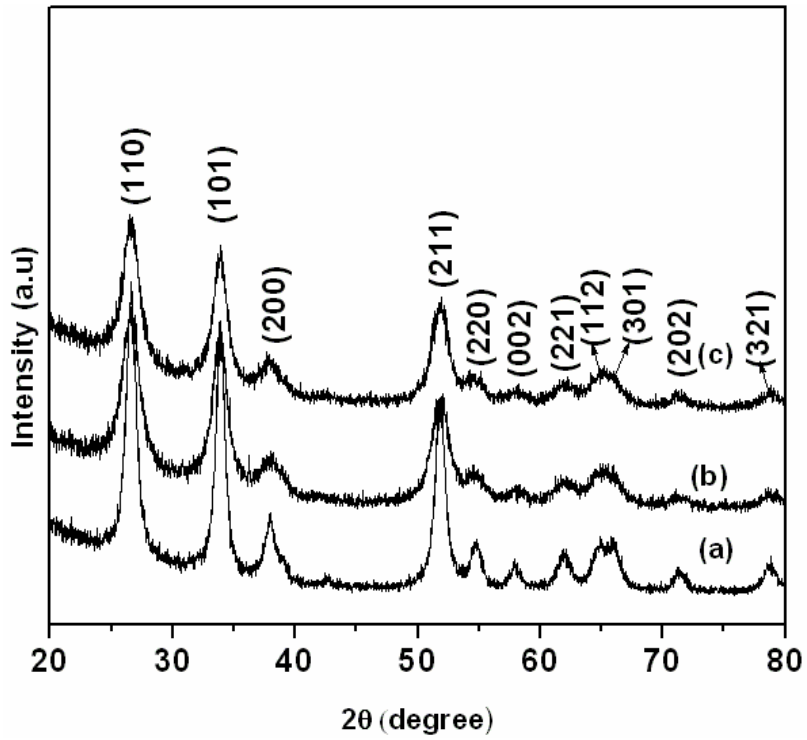


**Figure 1: XRD Example of a) Pure and b) Cu 10 wt. % c) Cu 20 wt. % Doped $SnO_2$. All the Three Examples have been Strengthened at 600°C for 5 Hours in Air**

The normal grain size of the nanoparticles was ascertained in light of Scherer's condition $d = \frac{k\lambda}{\beta \cos\theta}$

Where d is the mean crystalline size, K is the steady taken as 0.89, λ is the wavelength of the episode shaft, β is the full width at half most extreme.

**Table 1: Lattice Parameters of Unadulterated and Copper Doped $SnO_2$**

| Samples | a (Å) | c (Å) | Volume (Å$^3$) |
|---|---|---|---|
| Pure $SnO_2$ | 4.727 | 3.186 | 71.189 |
| $SnO_2$ + Cu10 wt. % | 4.725 | 3.185 | 71.107 |
| $SnO_2$ + Cu20 wt. % | 4.723 | 3.185 | 71.046 |

The normal crystalline size was observed to be around10 nm, 8 nm and 6.5 nm for immaculate and 10 and 20 wt. % Cu doped examples separately. This decline in grain size of $SnO_2$ recommends that the development is stifled because of doping of Cu into Sn-site [17].

**TEM Analyzes**

Figure 2 demonstrates the TEM photos of an) unadulterated b) 10 wt.% Cu and c) 20 wt.% Cu doped SnO2 nanopowders toughened at 600°C for 5 hours. Both immaculate and Cu doped specimens comprise of round molded nanoparticles. The normal molecule size of immaculate $SnO_2$ is around 8-11 nm. For Cu 10 and 20 wt. % doped $SnO_2$, the molecule size is between 7-9 nm and 5-7 nm individually. These outcomes are in great concurrence with the XRD results. Ming You et al. [17] have reported the normal molecule size of $SnO_2$ – CuO nanocomposites to be 80 – 90 nm, which is higher than the qualities got in the present work. The SAED "radiance" ring designs (Figure 2d) affirm that both the immaculate and Cu doped nanopowders are polycrystalline in nature.

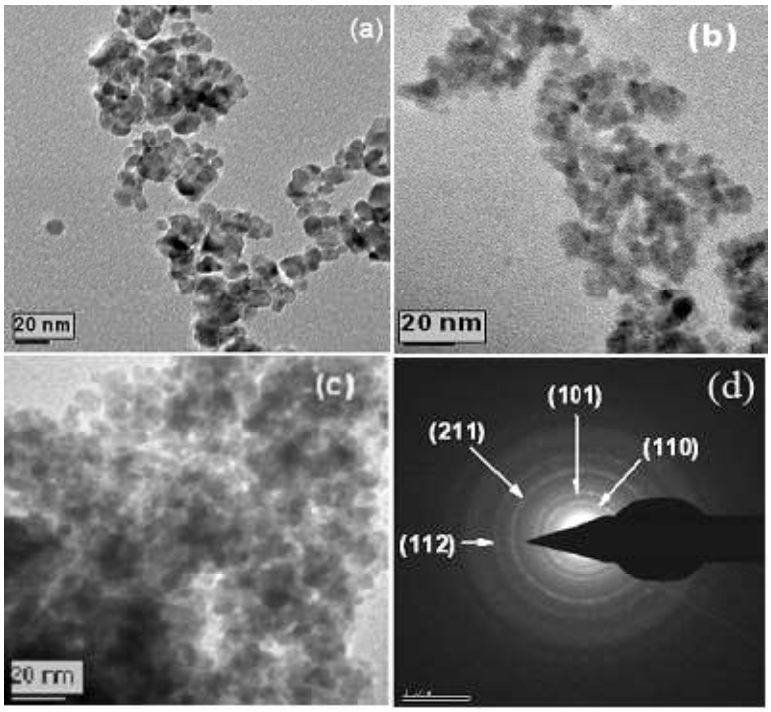


**Figure 2: TEM Micrograph of $SnO_2$ Powder a) Pure $SnO_2$b) Cu 10 wt. % c) Cu 20 wt. % Doped Specimens d) SAED Pattern of Immaculate and Cu-Doped $SnO_2$**

**UV-VIS Diffuse Reflectance Spectral Analysis**

Figure 3 demonstrates the UV-VIS diffuse reflectance spectra of unadulterated and Cu doped $SnO_2$ nanopowders strengthened at 600°C for 5 hours. The band whole energies figured utilizing Kubelka – Munk (K-M) model [18] is portrayed beneath. The K-M model at any wavelength is given by

$$\frac{K}{S} = \frac{(1 - R_\infty)^2}{2R_\infty} \equiv F(R_\infty)$$

F (R∝) is the so called remission or Kubelka – Munkfunction, where

**R∝ = R Sample / R Standard**

Where R is the rate of reflectance [19]. A chart is plotted between $[F(R\propto) h\upsilon]^2$ Vs hυ and the capture quality is the band hole vitality [20] (see in figure 4).

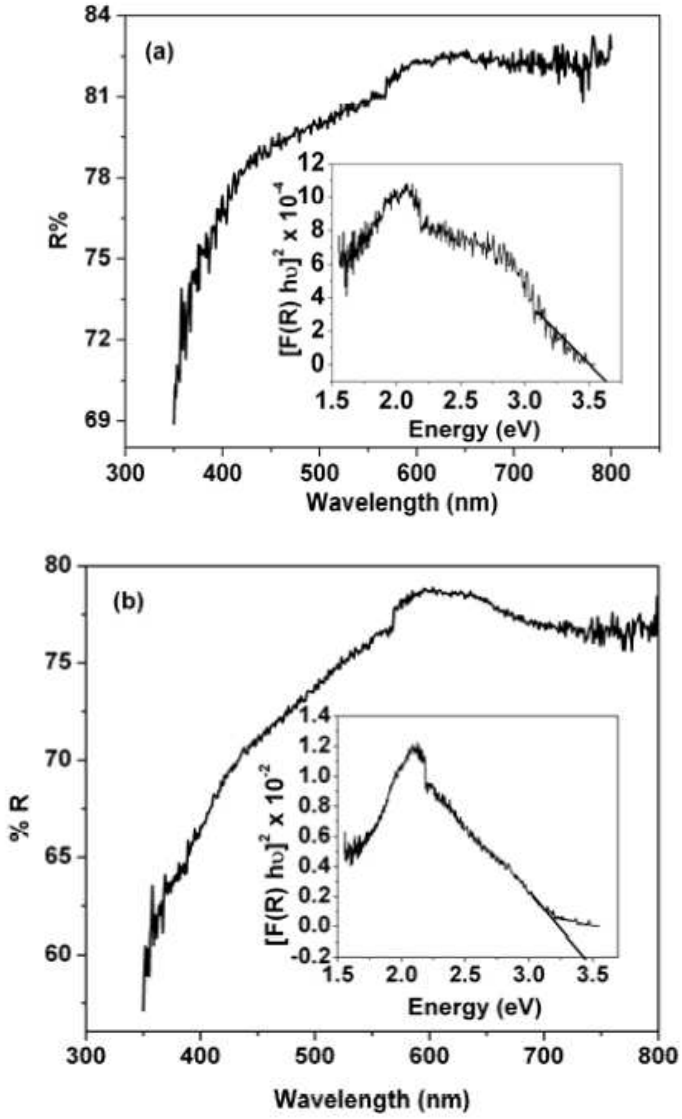


**Figure 3: UV-DRS Range of $SnO_2$ Powder a) Pure $SnO_2$ b) Cu (20 wt. %) Strengthened at 600°C for 5 h**

It can be seen that the spectra of Cu-doped $SnO_2$ showed an extensive red movement in the band crevice move with the expanding dopant content. The Eg esteem for immaculate $SnO_2$ is 3.56 eV, which is in great concurrence with the reported qualities [21]. The Cu doped $SnO_2$ materials display lower band whole energies of 3.31 eV and 3.28 eV for 10 and 20 wt. % separately. Comparable diminishing in the band crevice of $SnO_2$ has been accounted for doping with other move metals like Zn, Mg, Co, and in [22]. The watched diminish in band hole vitality can be ascribed to the charge-exchange moves between the copper particle S electrons and the SnO2 conduction or valence band.

**Resistance Measurement**

Figure 4 indicates resistance – temperature profile of immaculate and Cu 20 wt. % doped $SnO_2$ nanopowders toughened at 600°C. The integrated nanopowders were squeezed as pellet and anode contact was made utilizing silver glue.

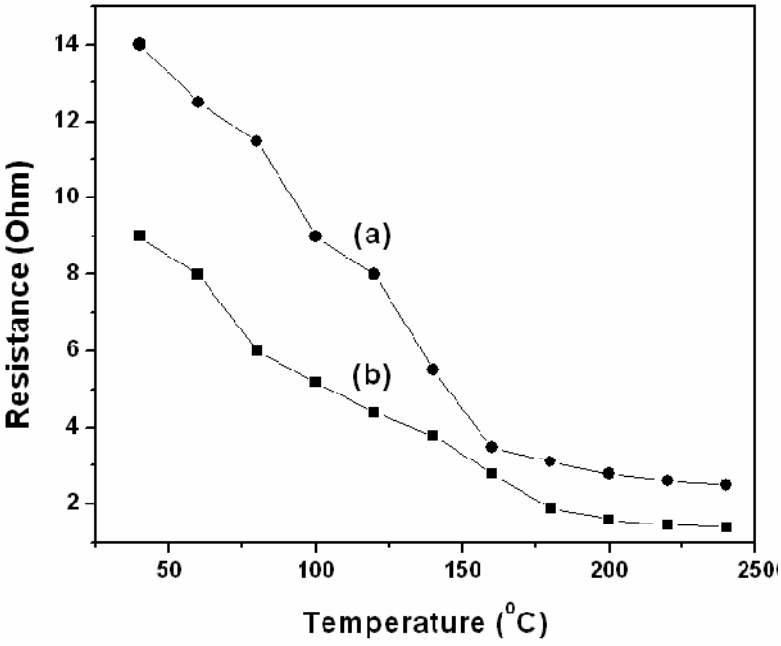


**Figure 4: The Variety of Resistance with Temperature for an) Unadulterated b) Cu (20 wt. %) Doped $SnO_2$ Nanopowders**

The abatement in resistance with expansion in temperature (above 50°C) could be ascribed to negative temperature coefficient and semiconducting nature of the immaculate and Cu doped $SnO_2$ nano powders. The Cu doped specimen demonstrates lower resistance than the immaculate $SnO_2$ material. This is because of the gift of free electrons by the Cu particles. The resistivity of unadulterated and Cu 20 wt. % doped $SnO_2$ at encompassing temperature was observed to be 13.18 Ω cm and 8.48 Ω cm which suggests the upgrade in electrical conductivity of Cu doped $SnO_2$.The result affirms that both immaculate and Cu doped $SnO_2$ materials were having great electrical reaction with temperature. These sorts of materials are best of gas detecting applications.

**Cyclic Voltammetric (CV) Measurement**

Figure 5 demonstrates the cyclic voltammogram investigations of unadulterated and Cu doped (20 wt. %) $SnO_2$ nanopowders. The electrochemical parameters, for example, cathodic crest potential (Epc) and anodic top potential (Epa) were measured. Both the unadulterated and Cu (20 wt. %) doped $SnO_2$ tests show irreversible oxidation just (cathodic crest 1.42V) and reversible lessening anodic top (- 0.5V) and cathodic (-0.9V) top.

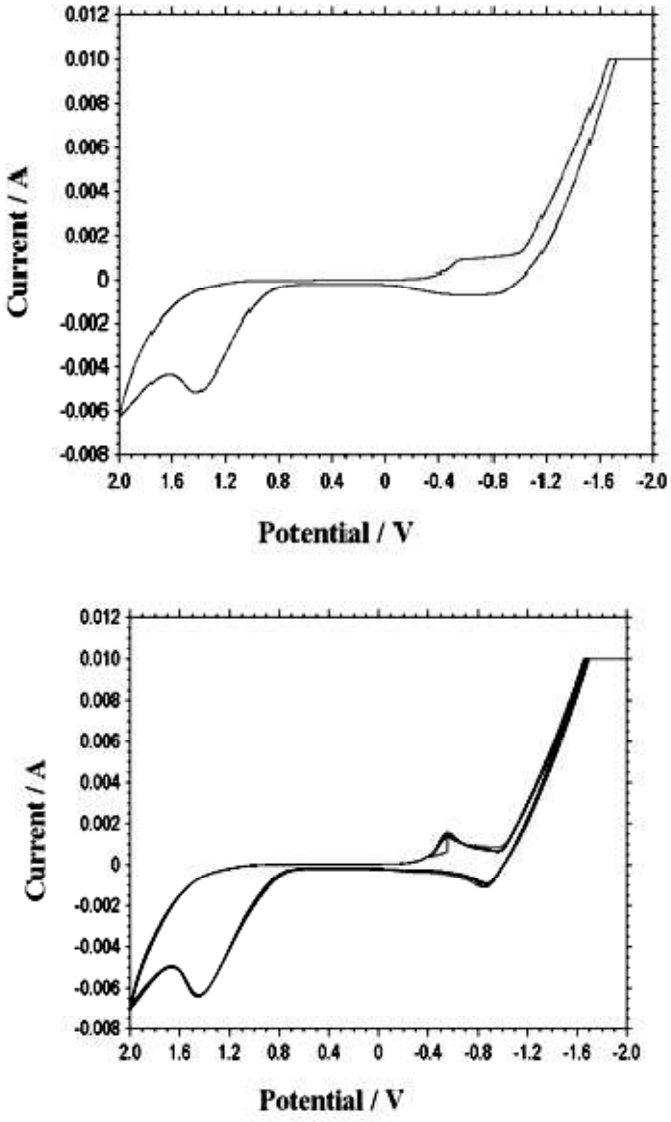


**Figure 5: Cyclic Voltammogram of $SnO_2$ Nanopowder an) Immaculate b) Cu (20 wt. %) Doped $SnO_2$ Nanopowders**

The diminishment crests are observed to be semi reversible in nature with top - to-top detachment esteem (Δ Ep is 400 mV). Taking into account this outcome, it can be presumed that both the specimens have electrochemical conduct. The cyclic voltammogram demonstrates that the crest positions of immaculate and Cu doped specimen is the same, however the Cu doped example the crest power is expanded. This infers the diminished metallic Cu improves the great electrochemical conduct when contrasted with that of unadulterated $SnO_2$.

## CONCLUSIONS

The immaculate and Cu doped $SnO_2$ nanopowders were set up by synthetic precipitation strategy. The normal crystalline size of immaculate $SnO_2$ was observed to associate with 10 nm. The precious stone structure of the $SnO_2$ does not change with the presentation of Cu, but rather the crystalline size declines to 8 nm and 6.5 nm for Cu (10 and 20 wt. %) individually. These outcomes are in great concurrence with the TEM results. The cyclic voltammetric contemplated affirmed that Cu doped example have great electrochemical conduct when contrast with unadulterated $SnO_2$ test. The UV-VIS dissemination reflectance spectroscopy (DRS) and temperature subordinate resistance results affirm the Cu doping

have positive impact on the optical and electrical properties of tin dioxide nanocrystalline material

## REFERENCES


1. S. Pan, C. Ye, X. M. Teng, G. H. Li, J. Phys. D:Appl. Phys. **40,** 4771 (2007)
2. H. Zhu, D. Yang, G. Yu, H. Zhang, K. Yao, Nanotechnology. **17,** 2386 (2006)
3. F. Du, Z. Guo, G. Li, Mater. Lett.**59,** 2563 (2005)
4. J. Duan, S. Yang, H. Liu J. Gong, H. Huang, X. Zhao, R. Zhang, Y. J. Du, Am. Chem. Soc.**127,** 6180 (2005)
5. Y. Liu, E. Koep, M. Liu, Chem. Mater.**17,** 3997 (2005)
6. Z .R Dai, J.L Gole, J.D Stout, Z. Wang, J. Phys. Chem. B **106,** 1274 (2002)
7. J. Q. Hu, X. L Ma, N. G Shang, Z. Y. Xie, N. B. Wong, C. S. Lee, S. T. Lee, J. Phys. Chem. B **106,** 3823 (2002).
8. F. Pourfayaz, A. Khodadadi, Y. Mortazavi, S. S. Mohajerzadeh, Sens. Actuators B **108,** 172 (2005).
9. A. Majid, J. Tunney, S. Argue, D. Kingston, M. Post,J. Margeson, J. Graeme, J. Sol-Gel Sci. Technol.DOI 10.1007/s10971-009-2108-x.
10. L. M. Fang, X. T. Zu, Z. J. Li, S. Zhu, C. M. Liu, L. M. Wang, F. Gao, J. Mater. Sci. Mater. Electron.**19,** 868 (2008).
11. H. Y. Jin, Y. H. Xu, G. S. Pang, W. J. Dong, Mater. Chem. Phys. **85**, 58 (2004).
12. C.T. Lee, F.S. Chen, C.H. Lu, J. Alloys Compd.**490,** 407 (2009).
13. G. Zhang, M. Liu, Sens. Actuators B **69**, 144 (2000).
14. P. S. More, Y. B. Khollama, S. B. Deshpande, S. K. Date, R. N. Karekar, R. C. Aiyer, Mater.Lett.**58**, 205 (2003).
15. C. X. Hu, Y. S. Wu, H. Y. Wei, Y. C. Shi,L. L. Wu, J. Mater. Sci. **40**, 6301 (2005).
16. Vivek Kumar, Shashwati Sen, K.P. Muthe,N. K. Gaur, S. K. Gupta, J. V. Yakhmi, Sens. Actuators B: Chemical **138,** 587 (2009).
17. M. A. Ming-you, H. E. Ze-qiang, X. Z. Bing,H. Ke-long, X. Li-zhi, W. Xiang-ming, Trans. Nonferrous Met. Soc China.**16,** 791 (2006).
18. H. Zhu, D. Yang, G. Yu, H. Zhang K. Yao, Nanotechnology. **17**, 2386 (2006).
19. G. Kortum, Reflectance Spectroscopy (Springer-Verlag, Newyork, 1969).
20. S. Mosadegh Sedghi, Y. MortazaviA. Khodadadi, Sen. Actuators B: Chemical. **145,** 7 (2010).
21. C. M. Liu, X. T. Zu, Q. M. Wei, L. M. Wang, J. Phys D: Appl. Phys. **39,** 2494 2006).
22. C. Drake, S. Seal, Appl. Phys. Lett**90,** 233117 (2007).